

SYNTHESIS OF COMPLEX ORGANIC MOLECULES DURING AN IMPACT. M. V. Gerasimov¹, E. N. Safonova¹, and E. A. Paskonova². ¹Space Research Institute, RAS, Profsoyuznaya, 84/32, Moscow, 117997, Russia, mgerasim@mx.iki.rssi.ru, ²Nesmeyanov Institute of Element Organic Compounds, RAS, Vavilova, 28, Moscow, 117813, Russia.

Introduction: Organic molecules can be produced by various natural processes and can be found in interstellar clouds, meteorites, comets, planets, etc. There is a large number of works showing the possibility of synthesis of complex organic molecules at reduced conditions under the action of various energy sources. The transfer of organic molecules from one space object to another is not so easy since the counteraction of space bodies usually occur at high velocities with release of large energies, which result in destructive for organics high temperatures. An impact of a meteorite into the Earth is generally considered as destructive process for organics because of the action of two factors: 1) high temperatures of vaporization at impact velocities over 10 km/s, and 2) oxidizing conditions of the environment, which are unfavorable for production of organic molecules. Earlier we reported about rather efficient synthesis of volatile organic molecules during simulated impact-induced vaporization of silicates in atmosphere of He and H₂ [1]. The formation of non-volatile organic components in such processes was indicated by the abundance of carbon in C-C and C-H bonding during investigation of the forming condensates by methods of X-ray-photoelectron-spectroscopy (XPS) [2]. The aim of the present work was to investigate experimentally the possibility of synthesis of complex organic molecules from initially inorganic carbon and hydrogen at oxidizing conditions during simulated impact-induced vaporization of silicates.

Experimental procedure: Our experiments were performed using standard laser pulse (LP) technique [3]. Special precautions were made to decrease the background level of organic pollution and to avoid contamination during experimental processing. A sample was placed into a hermetic stainless still cell with a special glass tube and plates, which formed internal glass compartment. The internal wall of the tube was covered by cylindrical Cu foil for collection of condensed products of simulated impact related vaporization of the sample. The cell was filled by air at room temperature and pressure. Organic products were extracted from the foil by n-hexane and were concentrated for analysis. Chromatographic analyses were done using gas-fluid chromatograph Perkin-Elmer F-22 with capillary column CP-Wax 58 CB 25 m × 0.25 μm I.D. × 0.2 μm. The column temperature was programmed from 60 to 240°C with 30 min at 240°C. A set of control analysis was done including check of

extractions of organic substances from solvents, chemicals, minerals, and all units, which contacted samples and internal cell compartment, and also blank experimental runs.

Samples: Experiments were performed with two sources of inorganic carbon and hydrogen. First, carbon and hydrogen were incorporated into the sample as inorganic component, and second, carbon and hydrogen free sample was vaporized in CO₂+H₂O atmosphere. The sample for the first case was made as a pressed tablet of powdered mixture of peridotite (90 % by weight) and MgCO₃·Mg(OH)₂ (10 %) and its vaporization was performed in the air. Peridotite was from mantle intrusions and had ~0.02 wt.% of inorganic carbon contributing ~2 % of total carbon.

For the second case we used mineral - augite.

Preliminary results: Chromatographic analysis have shown the presence of multiple organic components in the condensed material obtained at experimental runs and which were absent in control analyses (see Fig. 1.). It was possible to measure about a dozen of individual non-polar organic components most of which according to the time of delay of their output must have complexity up to 12 to 16 of carbon atoms. The quantity of all formed organic components was about ~10⁻⁷ g what corresponded to ~10⁻³ of the total amount of vaporized carbon.

Extracted organic material from an experiment with evaporation of augite in a CO₂+H₂O atmosphere was concentrated and placed in the evaporator of a mass-spectrometer. The evaporator was heated step by step from room temperature to 890°C. At every temperature step several mass-spectra scans were made to see the evolution of volatilized components. Examples of the mass-spectra are shown in Fig. 2. Mass-spectra demonstrate a wide variety of rather complex hydrocarbons with molecular masses up to 700. The separation of individual components from such mixed mass-spectra was highly difficult.

Discussion and Conclusions: Experiments show a rather efficient synthesis of complex organic molecules even at oxidizing conditions during an impact related vaporization of silicates. The amount of formed organic species is more than ten orders of magnitude higher than gas phase thermodynamic equilibrium concentration for such complexity of molecules [4]. We claim for heterogeneous catalysis on the surface of glass nano-particles which are condensing in the

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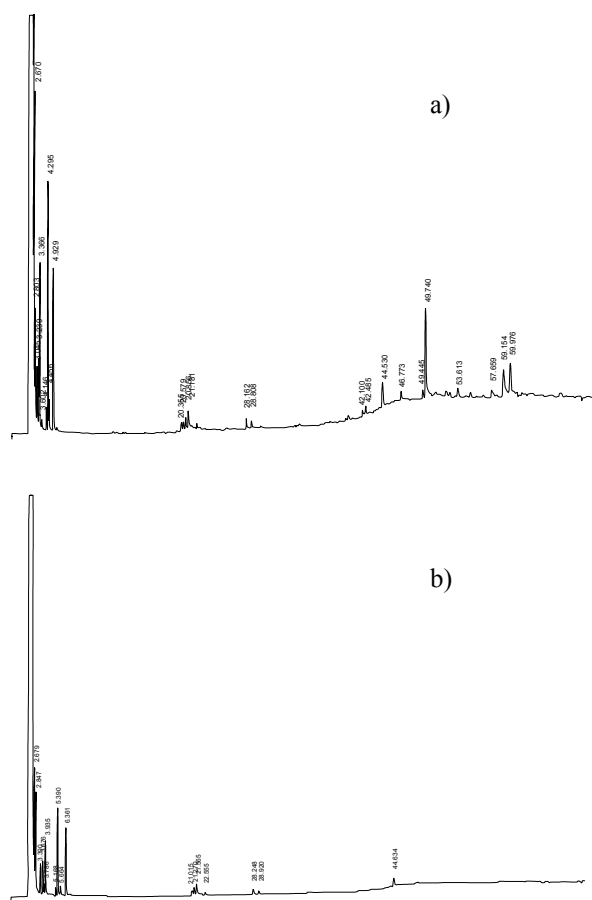


Fig.1 Chromatograms of organic compounds extracted from condensed material in LP experiment with peridotite(90%)+MgCO₃·Mg(OH)₂(10%) target (a) and from control analysis (b).

spreading cloud and fill-in its whole volume (see Fig. 3.). The possible mechanism here can be the Fischer-Tropsch-type of synthesis since more than a half of carbon during vaporization is converted to CO [1,4] and the dissociation of H₂O also produces a certain amount of H₂ and H. Organic molecule seems were mainly hydrocarbons but XPS analysis have shown that amino- and carbonyl- groups were also present in correlation with C-H bonds in the condensate in some LP experiments [5].

Independent of organic or inorganic nature of carbon in colliding material new complex organic molecules will be synthesized during an impact even at oxidizing environmental conditions.

Acknowledgment: This research was supported by RFBR grant 02-05-64419.

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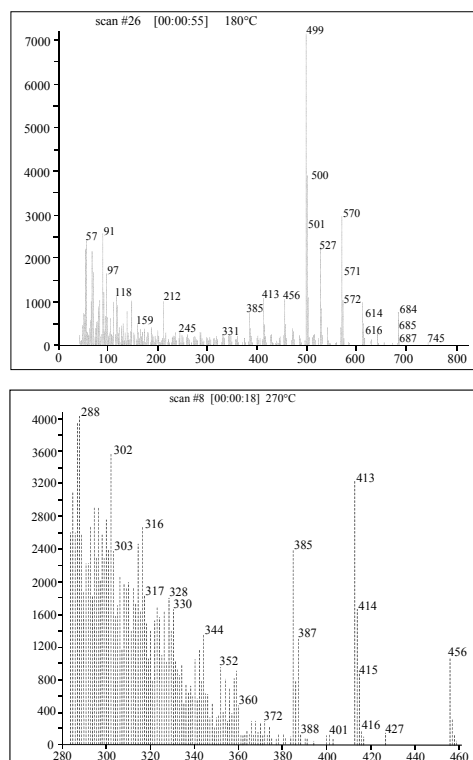


Fig. 2. Mass-spectra of hydrocarbons which were extracted from the condensed material after evaporation of augite in a CO₂+H₂O atmosphere. (a) An example of mass-spectrum at temperature of evaporator - 180°C. (b) A fragment of a mass-spectrum at temperature of evaporator - 270°C.

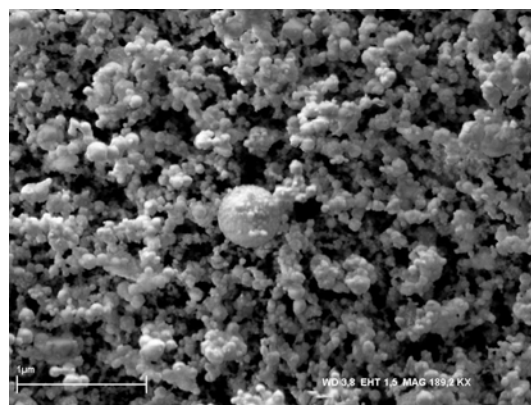


Fig. 3. SEM picture of the condensed material from LP experiment. The scale bar is 1 μm.